Fermilab Directorate

MEMORANDUM OF UNDERSTANDING
FOR THE 2002-2003 MESON TEST BEAM PROGRAM

T926

The Radio Ice Cerenkov Experiment

June 12, 2002

INTRODUCTION

The Radio Ice Cerenkov Experiment (RICE) seeks to measure Cerenkov radiation from ultra-high energy neutrinos with radio antennas buried in the ice at the South Pole. We detect the long-wavelength Cerenkov radiation signal resulting from mostly electron neutrino-induced showers. As the shower develops, atomic electrons in the target medium are swept into the forward-moving shower resulting in a net charge on the shower front. Such cascades produce broadband Cerenkov radiation for wavelengths larger than the transverse dimensions of the shower front that is coherent.[1] The RICE collaboration was undertaken initially based on predictions for measuring these neutrinos.[2] The RICE experiment presently consists of a 16-channel array of dipole radio receivers scattered within a 200m×200m×200m cube that is situated approximately 100-300m below the experimental station at the South Pole.[3]

A course of studies including accelerator testbeam runs has been undertaken by the RICE testbeam group and others to characterize the signals. A full Monte Carlo simulation has been undertaken. Initially the effort has been focused on the signal strength due to the electromagnetic shower evolution.[4] Efforts to test the electromagnetic shower evolution included: initial test beam studies using the final focus area at SLAC,[5] studies using a 15MeV beam at ANL,[6] and a first observation of the Askaryan effect by another effort at SLAC.[7] The last effort used picosecond pulses of GeV bremsstrahlung photons into a 3.5 ton silica sand target. They measured the polarization, coherence, timing, field strength vs. shower depth, and field strength vs. frequency.

Currently no experiments have been conducted to measure radio emission from hadronic induced showers although a previous Fermilab proposal was accepted by the PAC.[8] To order of magnitude, one expects that radio emission from PeV hadronic showers and electromagnetic showers are comparable, because almost all of the energy ends up at the “bottom” of the energy distribution with charge imbalances that are “order unity”. Hadronic showers are sufficiently different from electromagnetic showers that independent test should be done. The vast range of energies involved in a UHE shower and the intrinsic complexity of strong interactions make Monte Carlo estimates less reliable than corresponding electromagnetic shower calculations. Indeed, calculations for RICE thus far have conservatively omitted the hadronic contributions.

We have developed a test-beam proposal which can be used both for hadronic or electromagnetic circumstances.[9] This proposal takes into account symmetries so that we can exploit an exact mathematical calculation of the fields involved.[10] A bench-top prototype exists at the University of Kansas which has allowed us to tune our experimental setup. This MOU covers the first phase of these experiments using a similar small diameter (16 inches) aluminum tank. We will place two small (1 inch) dipole antennas inside the 15 ft long tank and read them out into an oscilloscope to characterize the signals found in the few hundred MHz region. By examining the phase difference and time variations between the signals of the two antennas, we can study the behavior of the electromagnetic pulse both in air and if the tank is filled with water. In order to guarantee enough shower development for the signal, it might be necessary to place a lead absorber in front of the tank.

This is a memorandum of understanding between the Fermi National Accelerator Laboratory and experimenters from the RICE group who have committed to participate in beam tests to be carried out during the 2002-2003 MTBF program. The memorandum is intended solely for the purpose of providing a budget estimate and a work allocation for Fermilab, the funding agencies and the participating institutions. It reflects an arrangement that currently is satisfactory to the parties; however, it is recognized and anticipated that changing circumstances of the evolving research program will necessitate revisions. The parties agree to negotiate amendments to this memorandum which will reflect such required adjustments.

I. PERSONNEL AND INSTITUTIONS:

Physicist in charge of beam tests: Alice Bean, Univ. of Kansas

Fermilab liaison: Erik Ramberg

The RICE Collaboration members at present and others interested in the testbeam are:

1.1 University of Kansas: C. Allen, A. Bean, D. Besson, D.J. Box, R. Buniy, D. McKay, L. Perry, J. Ralston, S. Razzaque, D.W. Schmitz, J. Snow, L. Christofek
1.2 Massachusetts Institute of Technology Lab for Nuclear Science: I. Kravchenko
1.3 Florida State University: G.M. Fricter
1.4 Bartol Research Institute: D. Seckel
1.5 University of Canterbury: J. Adams, S. Seunarine
1.6 Northern Illinois University: M. Cummins

Other commitments:
CLEO: D. Besson
D0: A. Bean, M. Cummins, L. Christofek
CMS: A. Bean, L. Christofek

II. EXPERIMENTAL AREA, BEAMS AND SCHEDULE CONSIDERATIONS

2.1 Location:
2.1.1 The experiment is to take place in the MTEST beam line and located in the area designated MT6-B3. In addition, the main control room to the west of the MTEST line will be used to house electronics (mainly an oscilloscope with an ethernet connection).

2.2 Beam:
2.2.1 We require protons at 3 energies: 120GeV, 100GeV, and 80GeV. We would also take runs with 30GeV pi+ and 30 GeV pi- beam tunes.
2.2.2 We require the maximum available intensity to the test areas, which is calculated to be 1MHz for the proton run. For the pi- and pi+ runs we understand the maximum intensity is 50kHz.

2.3 Setup:
2.3.1 We will install a scintillator trigger, an optional lead absorber, and the apparatus in the MT6-B3 area. The apparatus is a 16 inch diameter aluminum tube of wall thickness ¾ inch that is 15 ft. Flanges will be placed on either end of the tube so that the tube can be filled with water. On the downstream end of the tube, there will be insertions to allow us to take two RF cables out and position two dipole antennas inside of the tube. The tube will have to be mounted so as to support the approximately 2000 lbs when filled.

2.3.2 No significant space is needed for electronics near the beamline. At least one rack and one desk are needed in a nearby counting room.

2.3.3 Cabling to the counting room is minimal. There will be the scintillator trigger cable and then two RF shielded cables coming from the downstream end of the aluminum tube.

2.4 Schedule:

2.4.1 We are requesting a few days of setup time and then a few runs to accumulate around a few thousand events each. We expect that each run will take several hours. The runs we would like include: beam on and beam off with three different energy proton beams for empty tank and filled tank and with several runs for both pi+ and pi- beams.

III. RESPONSIBILITIES BY INSTITUTION - NON FERMILAB

([] denotes replacement cost of existing hardware.)

3.1 All equipment, DAQ, and computers will be supplied by the University of Kansas group:

3.1.1 Tektronix 2GHz digital scope with windows operating system and ethernet connection [$20K]

3.1.2 Laptop computer with ethernet [$3K]

3.1.3 Aluminum tube with flanges and supports [$1K]

3.1.4 Antennas with mounting structures inside of the tube and cables that connect to scope [$0.5K]

Total existing items [$24.5K]

IV. RESPONSIBILITIES BY INSTITUTION - FERMILAB

([] denotes replacement cost of existing hardware.)

4.1 **Fermilab Beams Division:**

4.1.1 Use of MTest beam.

4.1.3 Maintenance of all existing standard beam line elements (such as SWICs, loss monitors, etc) instrumentation, controls, clock distribution, and power supplies

4.1.4 Beam controls console and remote data logging capability (ACNET)

4.1.5 Reasonable access to our equipment in the test beam.

4.1.6 The test beam energy and beam line elements will be under the control of the BD Operations Department Main Control Room (MCR).

4.1.7 Position and focus of the beam on the experimental devices under test will be under control of MCR. Control of secondary devices that provide these functions may be delegated to the experimenters as long as it does not violate the Shielding Assessment or provide potential for significant equipment damage.

4.1.S Summary of Beam Division costs:

Type of Funds	Equipment	Operating	Personnel (person-weeks)
Total new items	$0K	$0K	0

4.2 Fermilab Particle Physics Division

4.2.1 The test-beam efforts in this MOU will make use of the Meson Test Beam Facility. Requirements for the beam and user facilities are given in Section 2. The Fermilab Particle Physics Division will be responsible for coordinating overall activities in the MTest beam-line, including use of the user beam-line controls, readout of the beam-line detectors, and MTest gateway computer.

		Equipment	Operating	Personnel (person-weeks)
4.2.2	Feedthrough for antenna into control room			
4.2.3	Support with welding the flanges on aluminum tube	$0K	$0K	.2
4.2.4	Support for helping to transport and mount the aluminum tube assembly	0	0	.4
4.2.4	Provision and support for filling and unfilling the aluminum tube with water	0	0	.4
4.2.8	Trigger scintillators with cables to KU Scope			
4.2.9	One lead brick to be used for absorber			
4.2.S	Summary of Particle Physics Division costs:			

Type of Funds	Equipment	Operating	Personnel (person-weeks)
Total new items	$0K	$0K	1

4.3 Fermilab Computing Division

4.3.1 A single connection to the wide-area-network will be required.

4.4 Fermilab ES&H Section

4.4.1 Assistance with safety reviews for radiation calculations and mounting of aluminum tube.

4.4.2 Testing for activation of the water in the aluminum tube after running and disposal of contaminated water if necessary.

V. SUMMARY OF COSTS

Source of Funds [$K]	**Equipment**	**Operating**	**Personnel** (person-weeks)
Beams Division	$0K	$0K	0
Particle Physics Division	0	0	1
Computing Division	0	0	0
Totals Fermilab	0	0	1
Totals Non-Fermilab	$24.5K		

VI. SPECIAL CONSIDERATIONS

6.1 The responsibilities of the Physicist in charge of RICE Beamtests and procedures to be followed by experimenters are found in the Fermilab publication "Procedures for Experimenters" (PFX). The Physicist in charge of RICE Beamtests agrees to those responsibilities and to follow the described procedures.

6.2 To carry out the experiment a number of Environment, Safety and Health (ES&H) reviews are necessary. The procedures to carry out these various reviews are found in the Fermilab publication "Review Procedures for Experiments" (RPX). The Physicist in charge of RICE Beamtests undertakes to follow those procedures in a timely manner.

6.3 All items in the Fermilab Policy on Computing will be followed by experimenters.

6.4 At the time of purchasing, the Fermilab procurement policies shall apply.

6.5 The Physicist in charge of RICE Beamtests will undertake to ensure that no PREP and computing equipment be transferred from the experiment to another use except with the approval of and through the mechanism provided by the Computing Division management. They also undertake to ensure that no modifications of PREP equipment take place without the knowledge and consent of the Computing Division management.

6.6 Each institution will be responsible for maintaining and repairing both the electronics and the computing hardware supplied by them for the experiment. Any items for which the experiment requests that Fermilab performs maintenance and repair should appear explicitly in this agreement.

6.7 If the experiment brings to Fermilab on-line data acquisition or data communications equipment to be integrated with Fermilab owned equipment, early consultation with the Computing Division is advised.

6.8 At the completion of the experiment:

6.8.1 The Physicist in charge of RICE Beamtests is responsible for the return of all PREP equipment, Computing equipment and non-PREP data acquisition electronics. If the return is not completed after a period of one year after the end of running the Physicist in charge of RICE Beamtests will be required to furnish, in writing, an explanation for any non-return.

6.8.2 The experimenters agree to remove their experimental equipment as the Laboratory requests them to. They agree to remove it expeditiously and in compliance with all ES&H requirements, including those related to transportation. All the expenses and personnel for the removal will be borne by the experimenters.

6.8.3 The experimenters will assist the Fermilab Divisions and Sections with the disposition of any articles left in the offices they occupied, including computer printout and magnetic tapes.

SIGNATURES:

________________________________ / / 2002
Alice Bean, University of Kansas

______________________________________ / / 2002
John Cooper, Particle Physics Division

______________________________________ / / 2002
John Marriner, Beams Division

______________________________________ / / 2002
Steve Wolbers, Computing Division

______________________________________ / / 2002
William Griffing, ES&H Section

_______________________________________ / /2002
Michael Shaevitz, Associate Director, Fermilab

_______________________________________ / / 2002
Michael Witherell, Director, Fermilab

APPENDIX I – RICE 2002-3 RUN PLAN

Assumptions:

2 days of setup time with experimenters working 8-12 hours per day and then a few days running with beam.

For each of the following runs, we will locate 2 dipole antennas in at least 4 different configurations, each of the 4 configurations will then require 1 hour of data taking for a total of 4 hours of beam in each run. There is a total of 9 runs x 4 configurations or 36 hours of real beam time. The runs can be performed in a different order than specified in order to optimize the beam time or water in/water out time.

Runs needed:

A. Beam off, water out
B. Proton beam, 120GeV, water out
C. Proton beam, 100 GeV, water out
D. Pi+ beam, 30GeV, water out
E. Pi- beam, 30 GeV, water out
F. Beam off, water in
G. Proton beam, 120 GeV, water in
H. Proton beam, 100 GeV, water in
I. Proton beam, 80 GeV, water in
J. Pi+ beam, 30 GeV, water in
K. Pi- beam, 30 GeV, water in

Let t_0 be the start date of the 2002 fixed target test beam program.

t_0 - 6 months	design mounting structure and protrusions for aluminum tube make sure all students have proper Fermilab training make a dry run to measure noise performance (assumed to take a few days) move aluminum tube into beamline area
t_0 -	Begin to commission
t_0 + 1 week	Complete first run period. Goals: Shakeout of DAQ, detector alignment, system noise, etc Run Plan: after commissioning of equipment is finished, will need about 2 days of intermittent data taking with beam to ensure that the data are sensible, alignment is good and system noise is what is anticipated. Then take a couple of days more of data
t_0 + 1 month	Analyze data to see whether more data taking is needed.

t_0 + 2 months — Start second run which may have detachable inner tube.

Goals: Run the tests as described in reference 9 with inner and outer beam tubes

Run Plan: Same as above, except there are now twice as many runs due to filling the inner and outer tubes separately.

APPENDIX II – OFF-LINE ANALYSIS PLAN FOR THE 2002 RICE BEAMTEST

DATA PROJECTION

We will read data into our Tektronix scope with an ethernet connection and onboard disk of 5 GBytes. Using two antennas and assuming that for each antenna for each event we readout 8 Kbytes of data, we will take 32 Mbytes per configuration which could be transferred to computers for analysis at the University of Kansas by ethernet from Fermilab or downloaded from the onboard disk at the end of the experiment.

ANALYSIS PLAN

All analysis will be done at the universities.

APPENDIX III - Hazard Identification Checklist

Items for which there is anticipated need have been checked

Cryogenics		**Electrical Equipment**		**Hazardous/Toxic Materials**	
	Beam line magnets		Cryo/Electrical devices		List hazardous/toxic materials
	Analysis magnets		capacitor banks		planned for use in a beam line or
	Target		high voltage (> 5 kV)		experimental enclosure:
	Bubble chamber		exposed equipment over 50 V		
Pressure Vessels		**Flammable Gasses or Liquids**			
	inside diameter	Type:			
	operating pressure	Flow rate:			
	window material	Capacity:			
	window thickness	**Radioactive Sources**			
Vacuum Vessels			permanent installation	**Target Materials**	
	inside diameter		temporary use		Beryllium (Be)
	operating pressure	Type:	Sr90		Lithium (Li)
	window material	Strength:	1 mCi		Mercury (Hg)
	window thickness	**Hazardous Chemicals**		X	Lead (Pb)
Lasers			Cyanide plating materials		Tungsten (W)
	Permanent installation		Scintillation Oil		Uranium (U)
	Temporary installation		PCBs		Other : Probably Al/ Cu/si
	Calibration		Methane	**Mechanical Structures**	
	Alignment		TMAE		Lifting devices
type:			TEA		Motion controllers
Wattage:			photographic developers	X	scaffolding/elevated platforms
class:		X	Other: Activated Water?		Others

APPENDIX IV - BIBLIOGRAPHY

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